Arizona Intelligent Vehicle Research Program - Phase One: 1997 - 2000

Final Report 473(1)

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16. Abstract –

This Phase One report documents a three-year research program by the Arizona Transportation Research Center to study possible practical applications of vehicle and infrastructure-based technologies. The project has reviewed, evaluated and demonstrated Intelligent Vehicle and Automated Highway System concepts that may improve the safety and efficiency of Arizona's highway system, particularly in winter maintenance operations.

The key accomplishment of Phase One was to develop a research partnership with the California Department of Transportation (Caltrans) in their Advanced Snowplow (ASP) program. The Caltrans prototype plow, guided by discrete magnetic markers in the roadway, features lane position indication, lane departure warning, and a forward collision warning radar system. The ASP has been tested through two winters, 1998–99 and 1999-2000. Training and evaluations have been conducted at the California test facility on Interstate 80 near Donner Summit, and at a second dedicated test site on US 180 near Flagstaff, Arizona.

This project report is presented in two sections. Section I gives a general history of the program, describing Arizona's interest and involvement in AHS and Intelligent Vehicle technologies through the summer of 2000. Section II of this report focuses in more detail on the Caltrans partnership, the site selection, the development of the magnet infrastructure in Arizona, and the initial two winters of testing and operational evaluation. The ADOT-Caltrans partnership, and the project, are ongoing in 2001 and 2002.

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METRIC (SI*) CONVERSION FACTORS

APPROXIMATE CONVERSIONS TO SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
in	inches	2.54	centimeters	cm
ft	feet	0.3048	meters	m
yd	yards	0.914	meters	m
mi	miles	1.61	kilometers	km
		AREA		
in^2	square inches	6.452	centimeters squared	cm^2
ft^2	square feet	0.0929	meters squared	m^2
yd^2	square yards	0.836	meters squared	m^2
mi^2	square miles	2.59	kilometers squared	km^2
ac	acres	0.395	hectares	ha
		MASS (weight)		
oz	ounces	28.35	grams	g
lb	pounds	0.454	kilograms	kg
T	short tons (2000 lb)	0.907	megagrams	Mg
		VOLUME		
fl oz	fluid ounces	29.57	milliliters	mL
gal	gallons	3.785	liters	L
ft^3	cubic feet	0.0328	meters cubed	m^3
yd^3	cubic yards	0.765	meters cubed	m^3

Note: Volumes greater than 1000 L shall be shown in m^3.

		TEMPERATURE (exact)		
°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C

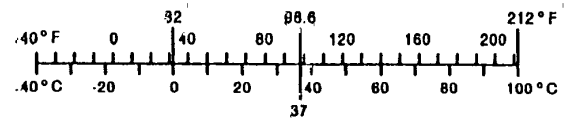
APPROXIMATE CONVERSIONS TO SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
mm	millimeters	0.039	inches	in
m	meters	3.28	feet	ft
yd	meters	1.09	yards	yd
km	kilometers	0.621	miles	mi
		AREA		
mm^2	millimeters squared	0.0016	square inches	in^2
m^2	meters squared	10.764	square feet	ft^2
yd^2	kilometers squared	0.39	square miles	mi^2
ha	hectares (10,000 m^2)	2.53	acres	ac
		MASS (weight)		
g	grams	0.0353	ounces	oz
kg	kilograms	2.205	pounds	lb
Mg	megagrams (1000 kg)	1.103	short tons	T
		VOLUME		
mL	milliliters	0.034	fluid ounces	fl oz
L	liters	0.264	gallons	gal
m^3	meters cubed	35.315	cubic feet	ft^3
m^3	meters cubed	1.308	cubic yards	yd^3

		TEMPERATURE (exact)		
°C	Celsius temperature	9/5 (then add 32)	Fahrenheit temperature	°F

These factors conform to the requirement of FHWA Order 5190.1A

*SI is the symbol for the International System of Measurements



EXECUTIVE SUMMARY

This Phase One report documents the first three years of an ongoing research program by the Arizona Department of Transportation (ADOT) to study possible practical applications of vehicle and infrastructure-based Intelligent Transportation Systems technologies. The ATRC (Arizona Transportation Research Center) has performed this project as an internal research effort. During Phase One of this project, from 1997 to mid-2000, ADOT and the ATRC have reviewed, tested, evaluated and demonstrated Automated Highway System (AHS) and Intelligent Vehicle (IV) concepts. These new resources may improve the efficiency of Arizona's highway system, and in particular, may enhance the safety and efficiency of winter maintenance operations.

This project has focused on a study area that offers significant near-term benefits to transportation agencies. With an extensive rural highway network and only limited resources to keep the roads open in the worst weather conditions, Arizona faces major operational challenges. Snow removal and emergency response operations are among the most critical and hazardous duties for highway maintenance personnel. Safety and efficiency improvements are greatly needed in the winter maintenance field, and real gains can be achieved with ITS and IV concepts.

The key accomplishment of this project in Phase One has been to develop a working partnership between ADOT and the California Department of Transportation (Caltrans), whose Advanced Snowplow partnership offered significant opportunities for both states to benefit. The Caltrans-ADOT snowplow features lane position indication and lane departure warning, as well as a forward collision warning system. A continuous line of discrete magnetic markers embedded in the roadway provides guidance information to the snowplow.

This guidance system, installed on a Caltrans 10-wheel 10-yard plow, has been tested through two winters, 1998–99 and 1999-2000. Training and evaluation activities have been conducted both at the primary California project testbed on Interstate 80 near Donner Summit, and at a second dedicated test site on US Highway 180 near Flagstaff, Arizona.

This project report is organized into two distinct areas of research activity. Section One provides a general overview of the project's inspiration and goals, and it discusses the early IVI efforts in Arizona. It also describes the accomplishments of the program in terms of increasing the agency leadership's awareness of these concepts, and of the potential benefits from future research.

Section Two of this report describes in detail the more focused winter maintenance needs and goals that led to the long-term snowplow evaluation partnership between ADOT and Caltrans. This section discusses the specifics of site selection and construction of the Arizona intelligent infrastructure site. It also details the snowplow testing and evaluation program and the project's Phase One results, conclusions and recommendations for future research.

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ADOT's I-40 Corridor District Engineers, Maintenance Engineers & Superintendents:

- Flagstaff – Don Dorman, John Harper, Danny Russell
- Holbrook – Jeff Swan, Robert Wilbanks
- Kingman – Debra Brisk, Bill Wang, Larry Thomas

Flagstaff District Team Leaders:

- Joseph Chavez, Tom Durnez, Don Dodge, Tyrone Begishie

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- Dr Ty A. Lasky, Dr. Bahram Ravani and the AHMCT project team.
- Dr. Wei-Bin Zhang, Dan Empey and the California PATH project team.

Project 473 Technical Advisory Committee:

During Phase One (1997-2000) the Research Project TAC represented the following ADOT sections and partner agencies; the complete list of TAC members is included as Appendix B.

- ADOT's I-40 Corridor Districts – Flagstaff, Holbrook, Kingman
- Arizona Department of Public Safety – Flagstaff DPS
- ADOT Transportation Technology Group (TTG)
- National Weather Service – Flagstaff -Bellemont
- ADOT Equipment Services
- Federal Highway Administration

The project also received very valuable support in the early activities from the ADOT Phoenix Maintenance and Construction Districts, and Jon Nelson of the VISION Field Office of the TTG.

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PROJECT ACRONYMS AND ABBREVIATIONS

Acronym	Definition
ACMS	Advanced Construction and Maintenance Systems
ADOT	Arizona Department of Transportation
AHMCT	Advanced Highway Maintenance & Construction Technology (Research Center at UC Davis – Prime Contractor for ASP)
APS	Applied Physics Systems
ASP-I	Advanced Snowplow, Phase I (Caltrans)
ASP-II	Advanced Snowplow, Phase II (Caltrans)
ATRC	Arizona Transportation Research Center (at Phoenix)
AVCSS	Advanced Vehicle Control and Safety Systems
AWMT	Advanced Winter Maintenance Testbed (Caltrans I-80 Site)
Caltrans	California State Department of Transportation
CWS	Collision Warning System
DGPS	Differential Global Positioning System
DOT	Department of Transportation
EMI	Electromagnetic Interference
FLD	Front Lateral Displacement
GPS	Global Positioning System
HMI	Human-Machine Interface
HOV	High-Occupancy Vehicle
HUD	Head-Up Display
ISTEA	Intermodal Surface Transportation Efficiency Act of 1991
I-40	Interstate 40 (in Northern Arizona)
I-80	Interstate 80 (in Northern California)
ITS	Intelligent Transportation Systems
ITSA	Intelligent Transportation Society of America
IV	Intelligent Vehicle
IVI	Intelligent Vehicle Initiative
LCD	Liquid Crystal Display
LIDAR	Light Detecting and Ranging
MMW	Millimeter Wave
MOE	Measure of Effectiveness
MP	Milepost
MSU	Montana State University (at Bozeman)
NAHSC	National Automated Highway Systems Consortium
NAU	Northern Arizona University (at Flagstaff)
PATH	Partners for Advanced Transit and Highways (at UC – Berkeley)

Acronym	Definition
RF	Radio Frequency
RFI	Radio Frequency Interference
RPM	Raised Pavement Marker
RTOS	Real-Time Operating System
SBC	Single Board Computer
UCB	University of California at Berkeley
UCD	University of California at Davis
US 89	US Highway 89 (NE of Flagstaff AZ)
US 180	US Highway 180 (NW of Flagstaff AZ)
WTI	Western Transportation Institute (at Montana State University)
3M	The 3M Corporation (Minnesota)